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ON THE CEREBRAL SINUSES AND THEIR VARIATIONS. BY J. F. KNOTT, F.R.C.S.I.

THE peculiarities in the cerebral circulation are so numerous and striking as to be obvious even to the most superficial observer. The most prominent were known to the older anatomists, but it is not a little remarkable how imperfectly they must have been examined, as some of the mistakes which are gravely put forward in their descriptions are absolutely ludicrous when read by the light of our present knowledge.

The veins of the brain being of large size and superficially situated at once meet the eye of the anatomist, and require comparatively little trouble for an investigation of their course. The most obvious peculiarities presented by these vessels when contrasted with the various canals of the other parts of the body are: the looseness of their connections with the surrounding tissues; their taking a course completely separate from that of the arteries; and their terminations in the peculiar dura-matral canals, into which they pass (at least in the case of the large proportion which open into the superior longitudinal sinus) in a direction opposed to that of the current within the receiving vessel. The absence of valves is a characteristic which they possess in common with most of the veins of the other cavities of the body.

The sinuses or dura-matral canals which receive the cerebro-meningeal veins were described with considerable accuracy by Galen, and it is curious to find that Vesalius, in times comparatively modern, and with better opportunities for examination of the human body, should have retrograded so much as to contradict Galen's account by asserting that the sinuses received arteries as well as veins, and that a pulsation was transmitted from the former. The mistake of Vesalius was refuted by Fallopius, but again revived and adopted by Vicussens, Wepfer, and other anatomists of this period, who were imposed upon by the facility with which injected fluid passed from the arteries into the sinuses. The minute and careful dissections of Albinus with the microscopic observations of Lieuwenhock, finally settled the question, and established the origin of the veins from

the capillaries at the termination of the arteries, in a way similar to the arterio-venous connection in other parts of the body.

These venous channels are peculiar in their outline, the deficiency of muscular and scantiness of elastic fibres in their walls, the absence of valves, the presence of tendinous strings, and, in some situations, of Pacchionian excrescences in their interior, and the contrariety of direction of a large proportion of their chief tributaries.

These blood-channels lie in the thickness of the dura mater, and are lined by a layer of endothelial cells prolonged from the internal membrane of the arteries and capillaries. Outside this is a thin layer of elastic fibres longitudinally arranged, while the remaining thickness of the coats is formed by the dura mater itself. In case of the greater number one part of the circumference of the vessel corresponds to the bone which is grooved for its accommodation. The layer of dura-matral fibres which lies next the lumen of the canal is in most cases longitudinally arranged, while a circular layer surrounds these, or, in many instances, a series of layers of circular and longitudinal bundles, which are exceptionally poor in yellow fibres. The individual and local varieties observable in the structure of the walls of the sinuses are very numerous, so that the description just given can only be regarded as that of the prevailing arrangement. A marked internal peculiarity is found in the existence of the so-called *Chordæ Willisii* which cross the lumen of some of these canals—the superior longitudinal, the cavernous, and the lateral. In the first-mentioned canal these form pretty strong tendinous cords; in the other sinuses they present a softer consistence and reddish colour. From the walls and Willisian cords of the cavernous sinuses little club-shaped villous processes project into the interior of its cavity (Hyrtil). There are some of about 2 millimetres in length, and a much greater number of about half.

The greater proportion of the veins from the convexity of the cerebral hemispheres enter the superior longitudinal sinus, and present the remarkable peculiarity that the direction of the majority is the reverse of that of the current of blood within the sinus itself. These veins, of which there are about twelve to fifteen on each side, pass obliquely backwards, and, as Lower long ago

observed, in most instances (although there are always a few exceptions), they pass obliquely between the walls of the sinus before opening into it like the termination of the gall-duct in the intestine or the ureters in the bladder. Ridley asserted that one-half of the tributaries of the sinus longitudinalis superior opened backwards.

Small masses of areolar tissue connect the pia mater to the dura mater for a little distance around the termination of each of these veins, and this connection arrested the attention of many of the older anatomists. Ridley calls them "*carnous adnescences*." Vicq d'Azyr confounds them with the glandulæ Pacchioni. Sir Charles Bell thus describes the intermembranous connection: "it is not a simple adhesion of the pia mater and dura mater; but a white spongy substance seems to connect and strengthen them, and, when torn asunder, it leaves a soft fatty kind of roughness upon the pia mater." Other small elevations or thickenings appear here and there along the falx cerebri, at or near the wall of the superior longitudinal sinus, but they are not constant or regular. Both these and the other spongy masses above mentioned have been erroneously included under the name of glandulæ Pacchioni. The structures which Pacchioni specially described, and which engaged him in a series of violent disputes with Fautonus, are situated *within* the cavity of the superior longitudinal sinus, and connected with the openings of the veins. He says of them "ovorum instar bombycinorum apparent," which describes their peculiarity of shape; he also notices their pale fleshy colour, which he attributed to an investment of muscular fibres. "In longitudinale sinu, immediate sub membranosis expansionibus, in areolis chordarum Willisianarum, quin et supra easdem chordas, consitæ sunt innumeræ glandulæ conglobatæ, propria, et tenuissima, membrana, veluti in sacculo conclusæ; quæ racemate ut plurimum cœunt; raro sparsine disponuntur: hæ glandulæ utrinque ad latera falcis messoria, ab ejusdem apice ad hasis usque posticam partem iniro prope modum artificio procedentes, dorso lacertorum accumbunt, et partim ab horum fibris, partim ab iis quæ a chordis emergunt, firmantur, atque invicem alligantur, ita at non nisi lacerat acu disjungi possint." Pacchioni believed that the ducts of these glandular bodies

passed to the pia mater, and conveyed a secretion which lubricated the surface of the brain. He also suggested that they were pressed, and their secretion promoted, by the motion of the chordæ Willisianæ and the action of the dura mater. Fautonus, who opposed Pacchioni's views so strongly, was of opinion that they gave out a fluid into the sinus which diluted the venous blood.

Sir Charles Bell suggested "that they had a valvular action on the mouths of the veins; they project from the mouths of the veins in the sinus, and the blood passing from the veins must filter through them, and be checked in its retrograde course." It is unnecessary to add that these views can now be of interest only to those who are curious to be skilled in the legendary lore of anatomical literature.

Turning to the consideration of the anatomical arrangement of the sinuses themselves, which forms the more immediate subject of this communication, we shall take as the starting-point the *confluens sinuum*, or so-called **torcular Herophili**, to which the great bulk of the intracranial blood is conveyed before it takes its definite downward course to the foramina of exit at the base of the skull. This cavity forms the point of union of the lateral, straight, occipital, and superior longitudinal sinuses, and is placed at the crucial spine of the occipital bone, in the majority of cases inclining a little more to the right side. Of those which I specially examined, twenty-seven specimens of forty-four were more to the right side, eight were mesial in position, nine had a slight inclination to the left. It forms an irregular cavity, the walls of which are mutually connected by strong Willisian chords. The ancient anatomists, ignorant of the true direction of the circulating blood, believed that the vital fluid, previous to passing into the brain, here underwent some mysterious process of elaboration, by which it was specially prepared for the nutrition of this important organ. "Cœuntes autem in vertice capitis, quæ sanguinem deducunt meningis duplicaturæ, in locum quendam vacuum quasi cisternam (quem sane ob id ipsum Hierophilus *torcular* solet nominare), inde velut ab arce quadam omnibus subjectis partibus vivos mittunt; quorum numerum nemo facile dixerit, quod partium nutriendarum numerus sit infinitus (Galen, *cap. vi. De torcular*).

The right-sided inclination of the torcular Herophili, as well

as the usually larger size of the right lateral sinus, were attributed by Lower, in comparatively modern times, to the practice generally recognised among nurses of usually laying children on the right side.

Other names which the imaginative nomenclature of the old anatomists has furnished to this venous cavity are *lacuna*, *platea*, *laguncula*, *pelvis*, *polmentum*, *tertia vena*, &c.

In the following notes the normal arrangement is compared with the variations observed in forty-four cases, in which the sinuses were carefully dissected:—

Sinus lateralis; *s. transversus* (Henle); *s. sigmoideus* (M. J. Weber); *s. tentorii posterior*.—This vessel receives as its tributaries the chief of the other sinuses, and is the great feeder of the internal jugular vein. It commences at the internal protuberance of the os occipitis, and, taking at first a horizontal course, passes outwards along the transverse part of the linea cruciata on the corresponding side. On leaving the occipital bone, it passes on to the posterior inferior angle of the parietal, from which it passes over the inner surface of the mastoid portion of the temporal bone, to groove the occipital a second time on the upper surface of its jugular process. Bending into the jugular foramen, it there joins the inferior petrosal and marginal sinuses to form the internal jugular vein. The transverse portion of the sinus presents the outline of a triangular prism, as it lies between the layers of the tentorium cerebelli. In the remaining part of its course it lies beneath the dura mater, and a transverse section is of semicircular form. The diameter of the vessel is considerable, averaging 8–10 mm. (W. Krause), but there is often a great inequality between those of opposite sides. The right is very generally the larger, but I have myself met with two instances of its almost complete absence, only a small venous canal of $1\frac{1}{2}$ mm. diameter following its course as far as the mastoid foramen, through which it disappeared. In the majority of cases the right is also longer than the left, and in four cases of the forty-four in which these sinuses were carefully examined, the superior longitudinal turned directly into the right lateral sinus, which appeared to be a direct continuation of the other. In these cases the left was only about one-third the size of the right lateral sinus.

Varieties.—The cases of diminutive size of the right lateral sinus have been already mentioned. Lieutaud has recorded a case of complete absence of the left lateral sinus, as far as the usual point of entrance of the superior petrosal sinus. The continuation of the latter with some tributary veins formed a diminutive representative of the lower part (*Essais Anat.* p. 332.) Both lateral sinuses may be small, and the greater part of the blood be transmitted along the occipital and marginal sinuses to the foramen jugulare to join the internal jugular vein. Henle alludes to this abnormality; there occurred one good example among the cases which I examined. A horizontal septum sometimes crosses the cavity of the sinus through a portion of its length, or even along the whole. In the latter case the channel is divided into two. Of this I have met two specimens, both occurring on the right side. This peculiarity was also observed by Hallett, who reported two examples (*Med. Times*, 1848).

Additional Branches.—*Emissarium occipitale.*—This venous canal passes through the occipital protuberances, communicating on the outside with the occipital veins, and on the inside with the *torcular Herophili*. A small vein could be distinctly traced through the bone in several cases (six in forty-four). In most of the others, there was found in this situation a small vein piercing either table of the occipital bone, and anastomosing with the diploic veins between, in this way representing the more distinct communication already mentioned.

An accessory sinus has been described by Kelch, which passes from the sphenoidal fissure backwards, crossing the upper border of the petrous portion of the temporal bone beneath the tentorium cerebelli, and beneath the superior petrosal sinus, with which it anastomoses in this situation. It then passes back on the under surface of the tentorium to join the lateral sinus, in which it ends (Kelch, *Beiträge zur Pathol. Anat.* 80). In front it communicates with some of the veins of the orbit. I have been able to trace a small vein along this course in three instances.

Vena aberrans.—Under this name Verga describes a channel of communication between the sinus cavernosus (or vena ophthalmica) in front, and the sinus lateralis sinister behind. I once found a vein occupying the corresponding position on the right

side, but have not met with the vessel which Verga describes on the left. (Verga, *Annal. Univ. di Med.* 1856).

Sinus ophthalamo-petrosus (Hyrtl).—Under this name Hyrtl describes a small occasional sinus which passes backwards from the sphenoidal fissure over the inner surface of great wing of sphenoid and anterior surface of petrous portion of temporal bone, to terminate in the lateral sinus. It sometimes leaves the skull through the foramen ovale, and in other cases it usually communicates with the middle meningeal veins. In four cases of the forty-four in which the sinuses were specially examined for variations, I was able to trace this vessel.

Sinus squamoso-petrosus (C. Krause), *s. petroso-squamosus* (Luschka).—This small vessel, when present, occupies the angle between the petrous and squamous portions of the temporal bone, and opens into the lateral sinus after crossing the posterior extremity of superior border of petrous bone, or passing through a canal in the latter. In front it pierces the squamous portion of the temporal bone, a little above the root of the zygomatic process, or perhaps the latter process itself, to communicate with the deep temporal veins.

In some cases it may be found to communicate with a small accessory sinus which passes through a canal in the bone, leading from the lower part of the sulcus transversus ossis occipitis to the mastoid foramen (Otto, *Seltene Beobachtungen*, 1824, ii. 70). This canal corresponds to the *canalis temporalis*, whose existence is normal in some mammals (Otto, *Nov. Act. Acad. Cas. Leop. Carol.* 1826, xiii. 23). This canal and contained vein I have found well developed in two instances only. As was first pointed out by Rathke, the study of the development of this bone throws additional light on the homology of the *canalis temporalis*, as a "*foramen jugulare spurium*," is found to be a normal opening in the corresponding part of the bone, during a great part of the embryonic period of the life of the human being.

This vessel (*sinus squamoso-petrosus*) is described by Sir Charles Bell under the name of the anterior petrous. He seems to have been familiar with its existence, and to look upon its occurrence as frequent; and it is strange that, like many other important venous canals, its existence should be ignored by the authors of so many of our anatomical hand-books. In the cases

which I selected for examination, seven of the forty-four bodies presented such a vessel on both sides, and nineteen others on one side only. Of the unilateral specimens eleven occurred on the left side, and eight on the right.

Sinus longitudinalis superior; (*s. sagittalis superior*; *s. falci-formis superior*; *s. triangularis*).—This reaches from foramen cæcum in front to internal occipital protuberance behind; or, as oftener happens, it turns, immediately before its termination, a little to one side to join one of the lateral sinuses, usually that of the right side. Through the foramen cæcum it communicates in early life with the veins of the nasal fossæ, but this anastomosis is usually cut off in the adult. In its course it occupies the median plane of the skull, passing backwards between the layers of the dura mater, which splits to enclose it, along the crista frontalis, sulcus frontalis, sutura sagittalis, and upper branch of the linea cruciata, on inner surface of occipital bone. Of thirty-eight calvaria on which I carefully examined the position of the groove which marked the course of this canal, I found it to occupy the median line as accurately as possible in nine specimens. In seven other cases it deviated only at the posterior extremity, terminating in the right lateral sinus in four, and in that of the left in three instances. In fourteen specimens the sulcus was more on the right side along the whole length of the sagittal suture, but in three of them it bent to the opposite side on the occipital bone, at about an inch and a half above the protuberance, to terminate in the groove for the lateral sinus. In two the termination was medial; in the others it was on the same side as the original deviation. In the remaining eight the sagittal groove was better marked on the left parietal bone, and in six it terminated in the corresponding lateral groove of occipital. In one case it gained the median line at the protuberance, and in one it crossed to the opposite side. The lumen of this sinus presents a distinctly triangular outline with a slightly concave base which is placed above, and its diameter gradually increases as it passes backwards, from 1·5 mm. at the level of the apex of the crista galli to 11 mm. at its termination. The diameter of the sinus is, however, subject to very great variations, the inconstancy of size being, indeed, the most striking feature in its abnormal anatomy. In some cases a

second small sinus may be found between the layers of the falx immediately below this normal superior longitudinal, or, in such cases it would be more accurate to describe the sinus as divided into two by a horizontal septum. The upper is thus quadrilateral in section; the lower is triangular with the apex downwards. The canals so arranged have been described by Malacarne under the name of *semi subalterni*. I have seen an instance of this division; it reached along the posterior half of the sinus only.

Varieties.—A case of complete absence of the superior longitudinal sinus is mentioned by Portal (*Cours d'Anat. Med.* iv. 29). This must, of course, be a very rare anomaly. I have not met with an instance, but I have certainly seen three specimens (out of forty-four in which it was carefully examined), in which the size was so small that it could hardly be looked upon as a representative of the normal sinus. The usual tributaries in these cases turned down between the layers of the falx cerebri, and joined the inferior longitudinal sinus, while the normal tributaries of the superior petrosal sinuses were larger than usual. In two the straight sinus received the termination of the superior longitudinal, which did not groove the occipital bone for the last inch of its course, but turned a little forwards as well as downwards between the layers of the falx.

The superior longitudinal sinus was found to bifurcate in two of the forty-four; in each case a little behind the coronal suture. The two branches re-united after a course of an inch and a half, in this manner enclosing a narrow ellipse. A similar case was reported by Vicq d'Azyr (Tab. xxxii.) Malacarne has recorded a case in which the superior longitudinal sinus bifurcated on reaching the apex of the occipital bone, and either branch followed the corresponding limb of the lambdoid suture to the junction with the temporal bone, when it joined the lateral sinus. The lateral sinus was then small up to that point. I have not met with an example of this strange anomaly.

Sinus longitudinalis inferior (*s. sagittalis inferior vel minor; s. falciformis inferior; vena longitudinalis inferior*). This canal (which hardly deserves the name of sinus as it more nearly resembles a vein in form) commences at a variable distance behind the anterior extremity of the falx cerebri, and passes backwards between the layers of this process of dura mater till

it reaches the anterior margin of the tentorium cerebelli where it joins the *sinus rectus*.

Varieties.—I have hardly found any notable abnormality in this sinus in any of the cases examined, the variations being confined to change of size and irregularity of position of origin. In one case, however, its termination was very peculiar. Instead of passing into the sinus rectus, it turned upwards between the layers of the falx to terminate in the superior longitudinal sinus, an inch and a quarter above the level of the internal occipital protuberance.

Sinus rectus; *s. quartus* (Galen); *s. perpendicularis* (Haller); *internal sinus* (Sir C. Bell); *s. obliquus*; *s. tentorii medius* (M. J. Weber).—This vessel, which is formed by the confluence of the inferior longitudinal sinus with the vena magna Galeni, passes backwards and downwards to join the *torcular Herophili*, or (what oftener happens) it may turn a little to one side to pass into one of the lateral sinuses. "It opens, for the most part, by an oval mouth, formed by strong pillars of fibres, into the left lateral sinus, rather than directly in the middle of the communication of the three great sinuses." Such is the description of its termination given by Sir Charles Bell, and it is entirely in accordance with my experience. In twenty-six cases out of forty-four it opened into the left lateral sinus, the terminal orifice answering exactly to the description above quoted. In six cases the deviation was to the right, while it ended medially in twelve instances. A vertical horizontal section at any part of its length presents a triangular outline with the base below, and apex above. The base is formed by the tentorium itself, while the sides are formed by the splitting of the layers of the falx cerebri. The diameter of this triangular canal is about 3–4 mm. for the greater part of its length, but is found to vary a good deal.

Varieties.—In one case I found this sinus completely absent. The vein of Galen and the inferior longitudinal sinus met at the anterior edge of the tentorium as in the normal arrangement, but the fusion was only for a length of about three quarters of an inch. From this point three veins passed backwards, one between the layers of the falx cerebri inclined upwards to join the superior longitudinal sinus an inch above the torcular, while the other two lay between the layers of the tentorium on the left side of the

attachment of the falx. One opened into the left lateral sinus half an inch beyond the margin of the falx; the termination of the outer one was an inch farther from the middle line.

Sinus spheno-parietalis (Bresehet); *sinus alæ parvæ*; *superior sphenoidal sinus* (Sir C. Bell).—This vessel arises from one of the meningeal veins at the outer extremity of the lesser wing of the sphenoid bone, and passes inwards under cover of the latter to terminate in the cavernous sinus. Its position is marked by a slight groove in the bone. It is of considerable dimensions, the diameter near its inner end being about 3 mm. I have observed great variability in the size of this venous canal, but in no case did I meet with an instance of its complete absence, a small vein at least was to be found in those cases where the normal sinus was not fairly represented. Accordingly I am surprised that a description is so often omitted from our text-books.

Sinus cavernosus; *receptaculum*; *s. caroticus* (Rektorzik); *confluens sinuum anteriorum*; *s. spheno-parietale* (Cruveilhier).—This is a space of extremely irregular outline, inclosed between the layers of dura mater on the lateral aspect of the body of the sphenoid bone, immediately above the root of the great wing. As already mentioned, it is crossed by fibrous trabeculae from some of which villous processes hang into the current of venous blood. In the layer of dura mater which forms its outer wall, several important nerves are included, while within the cavity, and in contact with the inner wall, is the carotid artery, which is separated from the venous canal only by the lining of the latter membrane.

Ridley describes in these words: "Another I discovered by having the veins injected with wax, running round the *pituitary gland* on its upper side, forwardly within the duplicature of the dura mater, backwardly between the dura mater and pia mater, then somewhat loosely stretched over the subjacent gland itself, and laterally in a sort of canal made up of the dura mater above; and the carotid artery on each outside of the gland, which, by being fastened to the dura mater above, and below at the basis of the skull, leaves only a little interstice betwixt itself and the gland." Brunnerus describes this sinus.

Varieties.—An example of complete absence of this sinus is

mentioned by Santorini (*Obs. Anat.* 1714, cap. iii. § 25). This I have not observed, but in some of those which I examined it was so small that it could hardly be looked on as a true representative of the normal cavernous sinus. This occurred in five cases, three of which were on the right side and two on the left.

An additional tributary, in the form of an emissary vein passing through the *canalis rotundus* of sphenoid with the superior maxillary nerve, has been described by Nuhn. This I have seen twice; in both cases on the right side. Another inconstant vein which lies in the *dura mater* on the inner surface of the great wing of the sphenoid bone, has been described by Sir C. Bell and some other anatomists as the *inferior sphenoidal sinus*. It was present in twenty-three of the forty-four subjects, fourteen on the right, nine on left side.

Sinus intercavernosus.—The receptacula of opposite sides are connected by means of one or more transverse vessels which cross the pituitary fossa. There are frequently two, one in front of the hypophysis, and the other behind. The anterior is the larger, the posterior is more often completely absent. Its absence was noted in twenty-six of my forty-four cases. In two of the others the posterior branch was the larger of the two, and in another case it was the only one present. In fifteen instances only did the above described arrangement of two transverse branches exist. When present they form with the cavernous sinus on each side the so-called

Sinus circularis (Ridley); *s. ellipticus*; *s. coronarius*; *clynoid sinus* (Sir C. Bell). A single vein forms the *sinus transversus sellæ equinae* described by Haller. A *sinus circularis inferior* is described by Winslow beneath the pituitary body, and formed by branches which take a course nearly parallel to the one usually described. I have found it in six cases only; in twelve others there was a single intercavernous vein beneath the pituitary body.

Sinus petrosus superior; *s. petro-basilaris* (Langer); *s. tentorii lateralis* (Weber); *s. petrosus superficialis*.—This sinus runs along the upper border of petrous bone between the layers of the tentorium, from the posterior extremity of the cavernous sinus in front to the lateral sinus behind. It joins the latter at the junction of its horizontal and descending portions. It

varies considerably in size. Its absence was noted in three cases; two of the right side, and one of the left.

A communicating *vas aberrans*, stretching between the ophthalmic vein in front, and the superior petrosal sinus behind, has been described by Verga (*Ann. Univ. di Medic.* 1856). I have found a vessel answering to this description in three instances; they all occurred on the left side.

Sinus petrosus inferior; s. p. profundus; s. petro-occipitalis superior (Trolard).—This canal passes from the posterior extremity of the cavernous sinus along the petro-occipital suture to the foramen jugulare. It descends through the anterior compartment of this foramen to join the internal jugular vein. With the purpose of ascertaining the exact level of its termination, I made a careful examination of the bases of eleven skulls after the dissection of the other sinuses had been completed. In eight of the twenty-two sinuses so inspected, the termination was as nearly as possible at the level of the lower margin of the jugular foramen, in nine instances it was a little above, and in the remaining five a little below that level. In two cases it terminated about $\frac{3}{4}$ ths of an inch below the base of the skull. In those which ended within the foramen, the termination was about the junction of the middle with the inferior thirds (in all cases).

Sinus petro-occipitalis inferior.—Under this name Trolard describes an external vein which passes backwards along the petro-occipital suture to terminate in the internal jugular vein.

Sinus transversus; s. basilaris (Cruveilhier); *s. fossæ basilaris* (Breschet); *s. basilaris anterior; s. occipitalis anterior; s. o. transversus; Plexus basilaris* (Virchow).—The so-called transverse sinus of our anatomical hand-books ill deserves the name, as it does not form a separate and distinct canal as in the case of the vessels already described. The name of plexus basilaris given to it by Virchow, is much more applicable. It is formed by a network of anastomosing veins, placed between the layers of the process of dura mater which covers the clivus. Some of these open into the inferior petrosal sinus on either side, some communicate anteriorly with the receptaculum or sinus intercavernosus posterior, while others pass downwards to the margin of the foramen magnum to anastomose with the anterior rachidian

veins. I have found no notable variation in their arrangement except in the varying size of the branches which go in the various directions named.

Sinus occipitalis; s. occipitalis posterior; s. basilaris posterior.—On account of the contradictory descriptions of this sinus given by different anatomists, I was specially desirous to ascertain what should be looked on as the normal disposition. Accordingly, I noted carefully the arrangement of the occipital venous canals in all the forty four cases in which I paid special attention to the sinuses. In two of these I could detect no trace of an occipital sinus. In nine cases the sinus was bilateral, one lying beneath the dura mater on either side of the internal occipital crest. In three of these both were very small, and ended below in an anastomosing network at the posterior lip of the margin of foramen magnum, through which a communication was established with the veins of the spinal canal. In two other cases the left was continued on as a *sinus marginalis* to join the lateral sinus at the jugular foramen, while the communication with the veins of the spinal canal was also present. In the other four the continuation of each was to the jugular foramen, while a few very small twigs passed down to join the spinal veins. In thirty-three cases the sinus was single, and occupied the median plane, or nearly so; eighteen of these commenced above at the torcular Herophili; seven opened into the left lateral sinus; five into the right lateral; three communicated with the sinus rectus about a quarter of an inch in front of the torcular. This median sinus descended between the layers of the falx cerebelli till it arrived close to the margin of foramen magnum. In seven cases it was unusually small, and had no further communication than that with the spinal veins. In all the others it split into two, and sent a branch to the jugular foramen along the sulcus marginalis to join the *bulbus venæ jugularis internæ*. In fifteen of these twenty-six the right sinus was somewhat larger than the left, the difference was not, however, very great. In only three cases was the left much larger than the other; in one of these it was about double its bulk. In the others they were as nearly equal as possible.

Of the so-called emissary veins, the following peculiarities were noted:—

Emissarium mastoideum.—The mastoid foramen for the transmission of a meningeal branch of the occipital artery, and a communicating vein between the occipital veins on the outside, and the descending part of the lateral sinus within the skull—pierces in the majority of cases (as its name implies) the mastoid portion of the temporal bone. In fourteen per cent. of my cases, the foramen was in the masto-occipital suture, and in three instances (out of eighty-eight) the corresponding vessels passed through a hole in the occipital bone itself, close to the suture. In thirty-four of the skulls, the foramen and vein were larger on the right side, in six on the left, in only four instances were they nearly equal. In none of these was it absent on either side, although in a few the size was diminutive; I have, however, seen absence of the foramen in five instances noted from time to time among my other dissections. Three of these occurred on the left side and two on the right.

Emissarium condyloideum.—This vessel passes through the canalis condyloideus (posterior condyloid foramen) forming a channel of communication between the lateral sinus, close to its termination, and the upper part of the plexus vertebralis cervicalis (veria jugularis posterior of Cruveilhier). In only thirteen of my forty-four skulls was it present on both sides. In twenty-one cases it was present on the right side, in ten on the left.

Emissarium parietale.—This vein passes through the foramen parietale between the superficial veins on the outside, and the sinus longitudinalis superior on the inside. It is accompanied by the ramus parietalis of the occipital artery. Both vessels and foramen are very often absent on one side, but I took no note of the proportion of cases.

Emissarium occipitale.—This vessel, which passes out on the external occipital protuberance, and communicates with the venæ diploicæ occipitalis within the substance of the bone, has already been noticed at sufficient length.

A prolongation of the sinus cavernosus into the canalis caroticus has been described by Rektorzik (*pars intra canalem caroticum des sinus caroticus*). It descends, breaking up into a plexus of small veins, which enclose the carotid artery at the lower part of the canal more or less completely, and for some distance below

the base of the skull. They then converge to form one or more trunks which open into the internal jugular vein. I have found in every case one or more small veins taking this course, from the lower part of the sinus cavernosus, so that they differ only in their degree of development, which was very variable.

Nuhn has called the attention of anatomists to a pair of veins which pass through the foramen ovale, communicate with the middle meningeal veins, and after forming a plexus around the commencing portion of the inferior maxillary nerve, terminate in the venous plexus of the infratemporal fossa. The satellite vein of the superior maxillary nerve described by this author has been already mentioned. The veins of the foramen ovale I have found very variable. In eighteen cases I found them to answer to his description on both sides. In six cases there were two veins on the right side and one on the left, in four the condition was reversed; the single vein in every case being nearly equal to the sum of the other two. In eleven instances, there was a single vein on each side. In five cases total absence on one side, three of these being on the right.

A vein or plexus of veins passes through the dense mass of connective tissue which fills the foramen lacrum medium, communicating with the cavernous sinus on the inside, and the external veins below the base of the skull. I have always found this communication when carefully searched for; the size and number of the vessels, however, vary very much.

Circellus venosus hypoglossi.—This is the name given by Luschka to the venous plexus which surrounds the hypoglossal nerve as it passes through the inner part of the anterior condyloid foramen. Two veins proceed from this plexus, one of which passes to the plexus vertebralis, the other goes to the sinus petrosus inferior. According to Trolard, they terminate in a vein commencing at the anterior condyloid fossa, to which he has given the name of *confluens condyloideum anterius*. But the truth is, as I have found, that either description may be correct, or a single vein may enter the confluens of Trolard, and the second pass to the inferior petrosal sinus, or plexus vertebralis. All these terminations I have seen, but have not made any note of their proportional frequency.